gen gas rendered incandescent, you would see a line of a certain thickness, with a certain pressure. Looking through the sun's coronal atmosphere in an eclipse, you pierce seven or eight hundred thousand miles of hydrogen gas. The thickness of the lines is the same. Various thicknesses of sodium vapour do not alter the thickness of the lines. But if we pass from metals to the metalloids, then certainly one is prepared to go on with the professor to any extent. I can show you how true his statement is photographically. There is considerable interest attached to the question whether there is or is not any chlorine in the sun's outer atmosphere. I have endeavoured to settle this question, contrasting the absorption chlorine spectrum with the solar spectrum; different thicknesses of chlorine have been employed. It seems that, if we take the metalloids, the absorption of a small thickness often takes place in the violet portion of the spectrum.

Now can these results be harmonised? Here I acknowledge we tread on very difficult ground, and with our present knowledge it would be perhaps best to say nothing; but I am not sure that this would not be scientific cowardice, so I will ask, under all reserve, whether the following explanation may not be a probable one? With metallic vapours the lines, though not widened as they are widened by great density, are certainly darkened, but all the lines are not visible—only the longest, generally. Now if we assume that the channelled space spectrum of the metalloids is really, even where it appears continuous, built up of lines,* then the darkening of these lines by greater thickness will not only make those darker that we see with a small thickness but bring others into visibility; and if this goes on till we have a very great thickness we may have an immense difference in the appearance of the spectrum.

11. *Some of the vibrations are very closely connected with others, as evidenced by repetitions of similar groups of lines in different parts of the spectrum.*

Here we are brought face to face with a revelation of the vibrations of particles, which, if I am not mistaken, will be made much of by the mathematical physicist in the future.

I will content myself by giving two or three striking instances, first noticed by Mascart. You will see that the longest line is at work in all of these.

In sodium we may say that the longest line is double; I refer to D′ and D″. All the lines are double.

In magnesium the longest line is a triple combination. This is repeated exactly in the violet.

In manganese we may almost say that the same thing happens, but the phenomenon is much more absolute in the case of those particles such as sodium and magnesium, which, on other grounds, I suspect to be of the simplest structure.

12. *Our knowledge of the vibrations of particles will be incomplete until the vibration is known from the extreme violet* (*invisible*) *to the extreme red* (*invisible*). In the meantime great help may be got from inferences, and, in the case of metalloids at low temperatures, from the position of their continuous absorption; and it is a question whether light may not be thus thrown upon the opacity of some solid substances and the transparency of others.

I think it not too much to say already, that in the case of some gases and vapours which are apparently transparent it is as certain in some cases that their absorption is in the ultra red, as it is certain that in the case of others the absorption is in the ultra violet. And further it is probable that this absorption is of the continuous or channelled space kind—in other words that no gas is "atomic" in the chemist's sense.

13. *From the fact that we have lines in the spectra of compound gases, it would be hazardous to affirm that the aggregate, which, with the highest dissociating power we can employ, gives us line spectra, could not be broken up if a still higher dissociating power could be employed.*

This proposition has a bearing on the celestial rather than on the terrestrial side of the inquiry, and as my time is drawing to a close I will refrain from enlarging upon it.

There is another branch of the research I am anxious to bring to your notice. I can do this better by experiment than by a simple statement.

The substance which you see here is a piece of gold leaf; it is yellow, as you know, but gold is sometimes blue and sometimes red. It must be perfectly clear to you, that if particles vibrate the colours of substances must have something to do with the vibrations. If the colours have anything to do with the particles it must be with their vibrations. Now as the spectrum in the main consists of red, yellow, and blue, the red and the blue rays are doing something in a substance which only transmits or reflects the yellow light; put the gold leaf in front of the lime light, you will see whether the yellow light does or does not suffer any change. The yellow has disappeared; you have a green colour; the red and blue are absent. The gold leaf is of excessive thickness. What would happen could I make it thinner? Its colour would become more violet. This I have proved by using aqua regia. But here is a solution of fine gold, which lets the red light through. Its particles are doing something with the blue vibrations, or *vice versâ*. Now what is the difference—the "particular" difference between the gold in this solution which is red, and that which is yellow by reflected, and green or violet by transmitted light? It is a question worthy of much study, especially in connection with my ninth proposition. Here are some more experiments. Here is some chloride of cobalt, which is blue. I will put it in this test-tube, to which I will now add water. You see it turns red. I content myself by asking why it turns red? We take some chloride of nickel, which is yellow, and put it into another test-tube: we add water, and I think you will soon see it turns green. First question—Why this change? Second question—Has the green colour of this solution anything to do with the red colour of the solution of gold?

I ask these questions because I believe the spectroscope will in time answer them.

I hope you will acknowledge that the spectroscope has to a great extent vindicated the theory stated by Prof. Maxwell. The question is, Has it taken us further? Perhaps not yet, but I think it will be found that what chemists picture to themselves as the atom, as contradistinguished from what they weigh, and physicists the molecule, is that particular atom, molecule, particle, or whatever name you may choose to call it, which with high-tension electricity gives us a spectrum of lines. You recollect that I said that in many of the monad metals it was obtained in the first stage of temperature; in the case of the dyads and metalloids with higher stages. If the true atom be that which gives a line spectrum, many anomalies will fall to the ground. These are questions the spectroscope raises. If you allow that in the line spectrum an atom is at work, in channelled spectra and continuous spectra molecular aggregations, you will see at once that Prof. Maxwell and others will be able to get a much sharper definition of atom and molecule than they have now; and though atoms are little things, you know they lie at the root of everything, and time spent in investigating them will not be lost.

J. NORMAN LOCKYER

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[*] Thalen's beautiful researches on the spectrum of iodine quite bear out this view.

A BOTANICO-GEOLOGICAL EXCURSION INTO THE GRAMPIANS

THE Scottish Alpine Botanical Club is wont to hold a spring meeting for mingled plant-hunting and conviviality in some Highland district where the Alpine flora can be reached at not too great a distance from oatcakes and whiskey. The Geological class in the University of Edinburgh is in the practice of terminating its labours for the winter by taking an excursion of a week's duration to some part of the country where professor and students can find interesting rocks, with enough of food (such as it may be) to eat, and of beds, or shake-downs, to sleep on. This year the two bodies, drawn together perhaps as much by animal spirits as by scientific enthusiasm, coalesced and held a conjoint gathering at Clova—a lonely hamlet on the Forfarshire Grampians, well known to botanists for the richness of its Alpine flora, and to geologists for its glacier relics and its ancient metamorphic rocks. The following notes by the respective leaders of the plant-seekers and the rock-hunters were communicated to the Edinburgh Botanical Society on the 14th ult.:—

1. *Botanical Notes by Prof. Balfour.*—On Friday, April 24, the botanists visited the lower part of Glen Fee and the western side of Glen Dole. They specially examined the rocks in Glen Fee, where *Oxytropis campestris* grows and along with the plant took specimens of the rock for the determination of the geologists. They also visited

the rocks at the upper part of Glen Dole, where *Astragalus alpinus* grows. These rocks are very rich in plants; they consist of remarkably twisted and contorted gneiss, specimens of which were collected. The vegetation of the glen was in an advanced state, and some plants were gathered in flower which rarely blossom so early. Among them may be mentioned—*Arctostaphylos uva-ursi*, *Vaccinium vitis-idæa*, *Anemone nemorosa*, *Saxifraga oppositifolia*, forming large pink patches on the rocks; *Luzula campestris*, *Empetrum nigrum*, *Eriophorum vaginatum*, and *Cardamine hirsuta*. Among the other plants noticed in flower in the glen at Clova were: *Ulex europæa*, *Sarothamnus scoparius*, *Genista anglica*, *Prunus avium*, and *Ranunculus ficaria*. Among the plants not in flower which attracted notice were: *Silene acaulis*, *Saxifraga hypnoides* and *aizoides*, *Draba incana*, *Pyrola media*, *rotundifolia*, *secunda*, *Oxyria reniformis*, *Gnaphalium supinum*, *Dryas octopetala*. The following ferns were also gathered: *Lastræa oreopteris*, *Athyrium filix-fœmina*, *Polystichum lonchitis*, *P. aculeatum*, *Polypodium alpestre*, *P. vulgare*, *Asplenium viride*, *A. trichomanes*, *Botrychium lunaria*, and *Allosorus crispus*. All the species of British Lycopods except *inundatum* were gathered. Mr. W. B. Boyd collected some good mosses, including *Trichostomum glaucescens*, confined to the rock in Glen Fee on which *Oxytropis campestris* grows. It occurred in considerable abundance and in fruit.

On Saturday 25 the party again went to Acharne, and thence up Glen Esk to Bachnagairn, and by Loch Esk to the White Water and Little Gilrannoch. Again the day was all that could be desired. The snow near the summits of the hills was very refreshing, and on one we had a sufficient extent of snow to give us the benefit of a glissade with our poles. This day the botanists and geologists kept together. We specially examined Little Gilrannoch, one of the rocky summits which is interesting as yielding the *Lychnis alpina*, one of our rarest Alpine plants, and associated with it dwarf specimens of *Armeria maritima* and *Cochlearia officinalis*, the Alpine variety, and *Luzula spicata*. The rocks were specially examined by the geologists.

On Monday 27 the botanists examined Loch Brandy and Loch Wharral, and the rocks around them. We noticed particularly the vast crevasse formed at the top of the Snubb by the separation of a great mass of rock, which is gradually giving way, and will ultimately be precipitated into Loch Brandy. *Saxifraga oppositifolia* was seen as formerly in fine flower. *Azalea procumbens* was also gathered. In Loch Brandy *Isoetes lacustris* and *Lobelia dortmanna* were met with. In ascending the mountains this day we saw a fine effect produced by the thick white mist resting in the valley, while we were on the mountain above it enjoying clear sunshine. Among the mosses collected by Mr. Boyd during the trip may be noticed—*Grimmia unicolor*, *G. donniana*, *Leucodon morensis*, *Andræa campestris*, and *Hypnum catenulatum*.

2. *Geological Notes by Prof. Geikie.*—The main object of the geologists of the excursion was to observe some of the phenomena of the metamorphism of the district, to note the more prominent minerals, to trace the remains of old glaciers, and to connect the general structure of the rocks with the forms of hill, valley, crag, and ravine into which they have been carved. Incidentally, however, they took part in some of the botanical work, their attention being specially directed to the Alpine flora and to the circumstances under which some of the rarer Alpine plants occur. There can be no doubt that, as pointed out by Edward Forbes, our Alpine flora is descended from that which was general over these islands during what is known as the last Ice age. It has been supplanted in the lower districts by the vegetation which has come in with a milder climate; and it survives on the bleak and cold mountain ridges only so long as it can find its congenial temperature there, or so long as the chills and mists of these high regions forbid the further ascent of the plants which, swarming over the country, have driven these northern forms step by step up into these high grounds. It is well-known that the Alpine flora is richer in individuals and in species in the eastern Grampians than anywhere else in Britain. A number of plants are found in no other part of the country, and even in that district several are restricted to mere isolated rocks in some glen or some bare mountain brow. The question proposed to the consideration of the geologists was whether any geological reason could be given for this remarkable distribution, and particularly whether or not the nature of the rocks had had anything to do with it.

Some attention was accordingly paid to the habitat of three of the rarer and more local species. The *Astragalus alpinus* was observed on hard quartzose schist, high up in Glen Dole; the crag on which the *Oxytropis campestris* flourishes is a mass of singularly twisted and gnarled quartzose gneiss, with hard siliceous ribs projecting from its surface and showing the crumpled nature of the rock. But in neither of these cases does the rock apparently differ from many other crags in the neighbourhood, where the peculiar plants nevertheless are not found. In the case of the *Lychnis alpina* a special case seemed at first to be made out in favour of a relation, or at least a coincidence of a local plant with a local rock; for the locality noted as the habitat of this rare plant was found to present shattered knobs of serpentine projecting through the turf, and on these knobs the *Lychnis* grows, together with the *Cochlearia officinalis* and the *Armeria maritima*. This rock was not observed by the party *in situ* in any other part of the district examined. Before it was quitted, however, one of the botanists, who strayed farther over the mountain, returned with a piece of mica-schist, as the rock on which the same plants were found growing only a short distance away. It appeared, therefore, probable that, at the most, difference of rock can have had but a very slight influence in the survival and present distribution of the Alpine flora.

A much more effective influence may be traced to the general physical geography of the country, and especially of the eastern as contrasted with the western districts. The richness of the Aberdeenshire and Forfarshire mountains in Alpine plants, as contrasted with those of equal elevation in Invernesshire and Argyllshire, has long been a familiar fact to botanists. The cause of this contrast seems referable not to any difference in rock and soil, nor to mere differences in height; it appears to be explicable by the much greater breadth of high ground in the east than in the west. Everyone who has ascended some of the Grampian ridges remembers the wide undulating moors which spread out before him at heights of 2,000 or 3,000 ft. The summits are not peaks, so much as huge swells or mounds rising higher than the rest of the vast tableland. In the western counties, however, the craggy mountains tower often into sharp ridges. They are deeply trenched by glens and arms of the sea, so that relatively a smaller area of land rises out of the ordinary lowland vegetation into the chiller regions above. Add to this that the Invernesshire and Argyllshire hills lie nearer to the warm winds and currents of the Atlantic, and that the Grampian uplands receive the prevalent south-westerly winds after they have been chilled by passing over many leagues of high cold mountain ground. It is in these eastern parts of the Highlands that snow lingers longest, widest, and deepest—a good index, indeed, of the greater severity of the climate. These facts are suggested as affording some explanation of the comparative abundance of the Alpine flora in that part of Scotland.

Why in that limited district certain plants should be restricted to mere isolated rocks is a question to which no intelligible and satisfactory answer can at present be given. But even more perplexing is the problem presented by the survival of maritime plants upon some of the highest and bleakest mountain-tops. In such portions the *Cochlearia* or scurvy grass, the *Armeria* or sea pink, with *Silene maritima* and *Plantago maritima*, are found abundantly. They are poor dwarfed forms, it is true, when compared with their contemporaries on the coast, so that the latter habitat is evidently more congenial to them than the bleak uplands. Descendants of the old arctic flora once indigenous in this country down to the sea-level, as it is in northern Scandinavia at the present day, how have they come to be left on our mountain tops? Were they maritime plants originally, and have they been carried up by the gradual elevation of the land? This would involve a former submergence of the country to a depth of at least 4,000 ft.—a limit much beyond that suggested by other geological evidence. Or did they form part of the generally distributed flora whereof some species keeping to the shores have been able amid bare rocks and salt spray to maintain themselves there ever since, while farther inland they have succumbed to the march of the invading Germanic flora, and have been allowed to struggle on in dwarfed and stunted forms only on the bare chill mountain tops, whither the invaders did not care to pursue them?

Some light might possibly be cast on these questions by an examination of the contents of our older peat-mosses. There is reason to suppose that some of these mosses may date back into Glacial times. It would be interesting to discover whether among the plants whose remains went to form the peat any northern species could be detected no longer living in this country, even in our Alpine zone. This line of inquiry is now being prosecuted in Scandinavia, and it is suggested to the botanists of Scotland as a fit subject for their attention.

The more purely geological work by the brethren of the hammer during this excursion, whether when with the botanists among the Grampians or afterwards by themselves along the shore between Dunnottar and Aberdeen, is hardly appropriate in a communication to the Botanical Society.

ON THE FERTILISATION OF CERTAIN LABIATÆ

In the early part of April of the present year I had an opportunity of watching somewhat closely the mode of fertilisation of some species of Labiatæ, on which some notes may be interesting. The species observed were the three most abundant of the early flowering representatives of the order, *Lamium album*, *L. purpureum*, and *Nepeta glechoma*; the post of observation a bank covered by the three species growing completely intermixed, just outside a cottage-garden where were several hives of bees; the time occupied, several hours on three sunny mornings. The point which interested me most was the constancy with which the same species of insect confined its visits to the same species of flower, notwithstanding the close proximity in which the three were growing, this being perfectly in harmony with Mr. Traherne Moggridge's observations of a similar character respecting the visits of insects to fumitories and other flowers.

My conclusion is not based merely on actually noticing the visits of insects, but on the microscopic examination of the pollen collected on the captured insects. For this purpose the pollen-grains of the three species named offer unusual facilities, those of *Lamium album* being yellow, of *L. purpureum* red, and of *Nepeta glechoma* white.

In *Lamium album* the length of the style is such as to bring the stigmatic surface exactly on a level with the anthers of the shorter pair of stamens, as represented in Fig. 1; one branch of the style is nearly straight and is hidden among the anthers, the other projects at right angles into the opening to the tube of the corolla, so that it must necessarily be struck by any insect entering the flower. The only visitors to the flower seen were two species of humble-bee, *Bombus pratorum** (female) and *Anthophora retusa* (female), the former in large numbers, the latter much more rarely. From the position of the stigmatic surface, both it and the stamens must be struck by about the centre of the head of the bee; and it was on this part that the greater number of pollen-grains were found, and proved to belong exclusively to this species. In no single instance was a hive-bee seen to visit the flowers; Müller states that they obtain the honey from this species entirely by sucking it through holes bitten in the corolla by *Bombus terrestris*.

In *Lamium purpureum* the difference in length between the two pairs of stamens is less considerable and the anthers are consequently closer together, both branches of the style being bent forwards into the mouth of the corolla, as shown in Fig. 2. Although hive-bees were constantly hovering over the flowers, in no single instance did I see either them or the humble-bees visit this species; the only insect observed to settle on it being a butterfly (*Vanessa urticæ*) twice.

The position of the parts in *Nepeta glechoma* is very different. The two pairs of anthers are at a considerable distance from one another (Fig. 3), and the length of the style is such as to bring the stigmatic surface considerably beyond the longest pair, and projecting beyond the mouth of the much smaller corolla. The flowers were profusely visited by the hive-bees from the other side of the hedge. On no single occasion did I see the *Bombus pratorum*, of which such numbers were flying about, even attempt to enter the flower, and the smaller species, *Anthophora retusa*, only twice; and on each of these occasions she immediately came out again and began industriously to wipe the pollen off her head with her fore-legs, as if she disliked it. Owing to the much smaller size of the flower, and the greater length of the style, the part of the body of the bee touched by the stigma is very different to that in the *Lamium album*, namely, the back of the neck or even of the thorax. Hence even if the insect should visit the two species on the same journey—which, I should infer, is not usual—the pollen of one species would not easily be wiped off on to the stigma of the other. I did not observe any plants of the ground-ivy with the "female" flowers described by

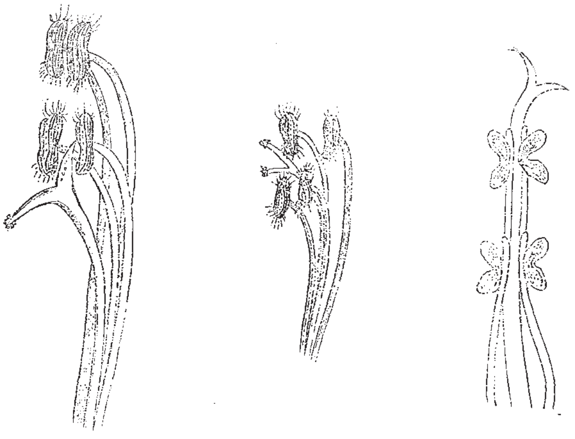

FIG. 1. FIG. 2. FIG. 3.

FIG. 1.—*Lamium album*; stamens, style, and stigma. FIG. 2.—*Lamium purpureum*; stamens, style, and stigma. FIG. 3.—*Nepeta glechoma*; stamens, style, and stigma.

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* In this and all other instances I am indebted for the determinatio the insects to the kindness of my friend Mr. Edward Newman.